TTF Survey of Galaxy Populations

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Abstract: The TAURUS Tunable Filter (TTF) affords a new approach to observational cosmology, allowing a wide field (10 arcmin) to be imaged monochromatically in contiguous wavelength intervals (6–60 Å bandpass) over the R and I bands. In a 200 s exposure with the AAT, the TTF can detect Hα emission powered by star formation rates as low as $0 \cdot 1\ M_\odot\,\mathrm{yr}^{-1}$ at $z = 0 \cdot 08$ and $1\ M_\odot\,\mathrm{yr}^{-1}$ at $z = 0 \cdot 24$ in 2 arcsec seeing (cf. $0 \cdot 26\ M_\odot\,\mathrm{yr}^{-1}$ for the LMC). In this paper we describe an emission-line survey currently under way using the TTF on the AAT to detect redshifted Hα over the ranges $z = 0 \cdot 06$–$0 \cdot 1$ and $z = 0 \cdot 22$–$0 \cdot 26$. Such detections will be of timely interest to the Southern H I Sky Survey which is motivated along similar lines.

Keywords: cosmology: observations — galaxies: surveys — galaxies: emission-line — instrumentation: Fabry–Perot

1 Introduction

The TAURUS Tunable Filter (TTF) is a new facility at the AAO that allows fully monochromatic narrowband imaging over an arbitrary bandpass (6–60 Å FWHM) at R and I bands. This instrument combines the flexibility of an ordinary Fabry–Perot interference filter to scan in wavelength with the widefield monochromaticity of fixed narrowband interference filters. Unlike an ordinary Fabry–Perot. however, the TTF works at orders low enough that a single interference ring covers almost all of the detector area.

The strength of the TTF is its unique ability to detect faint emission-line sources over a useful area on the sky. These are emission-line sources that would otherwise be lost within background sky noise on broadband images. We intend to exploit this facility as a means of probing for faint field and cluster emission-line galaxies (ELGs) at cosmologically interesting distances.

2 Survey Motivation

One of the current problems of observational cosmology is the inability to reconcile the large numbers of blue galaxies seen at faint magnitudes [see Koo & Kron (1992) for a review, and more recent work by Lilly, Cowie & Gardner (1991) and Metcalfe et al. (1995)] with the results of recent spectroscopic redshift surveys (Ellis et al. 1996, and references therein). These surveys ($B \lesssim 24$) indicate that the majority of these objects lie at modest redshift ($z \sim 0 \cdot 3$) rather than the high redshifts originally expected. While simple no-evolution (NE) models of the universe are able to account for the slope of the observed redshift distribution, the number counts of these faint blue galaxies (FBGs) to faint limits ($B \sim 28$) are well in excess of those predicted by NE models. Furthermore, it appears that the number count data are more easily modelled with the use of a non-zero cosmological constant and $q_0 \neq 0 \cdot 5$, both of which are disfavoured options from a theoretical standpoint (Schade & Ferguson 1994).

Ellis et al. (1996) claim that the excess population of galaxies at $z \sim 0 \cdot 3$ is primarily due to a *separate* population of star-forming galaxies characterised by broad [O II] equivalent widths, a suggestion first made by Broadhurst, Ellis & Shanks (1988) and later confirmed by Broadhurst, Ellis & Glazebrook (1992) as the spectroscopic studies increased in depth. No such equivalent population has yet been detected locally ($z \lesssim 0 \cdot 1$). This is a crucial issue in the interpretation of the excess FBG counts, for if local galaxy samples are incomplete (e.g. due to surface brightness selection effects) then an *artificial* excess in the galaxy counts will appear at higher redshift (Schade & Ferguson 1994). The TTF Field Galaxy Survey aims to place stronger constraints on galaxy SFRs and luminosities both at $z \sim 0 \cdot 25$ where the FBG excess is observed, and at $z \lesssim 0 \cdot 1$ where an equivalent local population has long been suspected but not observed.

3 Observing Strategy

We are undertaking a volume-limited survey for
Hα line emission from galaxies within two intervals
of redshift: $0\cdot064 \leq z \leq 0\cdot101$ (interval A) and
$0\cdot225 \leq z \leq 0\cdot259$ (interval B), using the 10 arcmin
field of the TTF. Although the primary target
of the survey is Hα emission, the survey will
also be sensitive to emission from redshifted [O II],
Hβ, [O III] and possibly Lyα. Table 1 summarises
the scanning parameters of the TTF for each
interval.

The intrinsic Hα line strength in a quiescent
galaxy can be related to the current rate of massive
star formation present (Kennicutt 1983). Figure 1a
shows apparent Hα luminosities, $F_{H\alpha}$, as a function
of redshift for galaxies with star formation rates
(SFRs) between $0\cdot01$ and $10\,M_\odot\,yr^{-1}$. We have
assumed $H_0 = 75\ km\,s^{-1}\,Mpc^{-1}$, $\Omega_0 = 0\cdot2$ and
$\Lambda_0 = 0$ throughout. Figure 1b shows the signal-to-
noise ratio (S/N) per pixel that we expect to attain
using the TTF for galaxies with SFRs between $0\cdot1$
and $10\,M_\odot\,yr^{-1}$. We have assumed emission from
galaxies at redshifts of $0\cdot08$ (interval A; solid curve)
and $0\cdot24$ (interval B; dashed curve). Typical values
of dark current, read noise and sky background
during bright time have been used with a combined
AAT/TTF/CCD efficiency of 17 %. Since a typical
star-forming region in an LMC-type dwarf is about
300 pc in diameter, we expect the emission-line

regions to be spatially unresolved and so Figure 1b
assumes 2 arcsec seeing.

As Figure 1b shows, SFRs as low as $0\cdot1\,M_\odot\,yr^{-1}$
at $z = 0\cdot08$ and $1\,M_\odot\,yr^{-1}$ at $z = 0\cdot24$ can yield
a 3σ detection in only 130 s of exposure time. By
way of comparison, a low-activity Sb spiral such as
the Milky Way has a SFR of $\sim 5\,M_\odot\,yr^{-1}$ (Smith,
Biermann & Mezger 1978) while the LMC has a
rate of $0\cdot26\,M_\odot\,yr^{-1}$ (Kennicutt et al. 1995). We
have settled upon an exposure time of 200 s per
slice as a compromise between flux limit and sky
coverage. Exposures of this duration allow us to
obtain Hα fluxes to $\sim10^{-15}\ erg\,cm^{-2}\,s^{-1}$ ($\sim10^{-26}$
$W\,m^{-2}$) as Figure 1a shows.

4 Scientific Returns

The TTF Field Galaxy Survey aims to cover $0\cdot56\ \square^\circ$
on the sky ($\sim13200\ Mpc^3$), the returns from which
we expect to be numerous. First, the survey
promises unprecedented detection of Hα emission
in the separate star-forming galaxy population at
$z \sim 0\cdot3$, thereby providing a quantifiable and
independent confirmation of its extent compared to
the [O II] detections of recent spectroscopic surveys.
Second, we expect to extend the current limits for
detection of distant emission-line galaxies, due to our
low background advantage and high line/continuum
ratio compared to those in broadband surveys.
Finally, at $z \sim 0\cdot1$ we are probing for Hα emission

Table 1. Scanning parameters used in the survey

Interval	Wavelength range (Å)	Hα redshift	No. of slices	Scan step (Å)	FWHM* (km s^{-1})
A	$\lambda\lambda$6980–7227	$0\cdot064 \leq z \leq 0\cdot101$	27	9·5	311
B	$\lambda\lambda$8040–8264	$0\cdot225 \leq z \leq 0\cdot259$	19	12·5	369

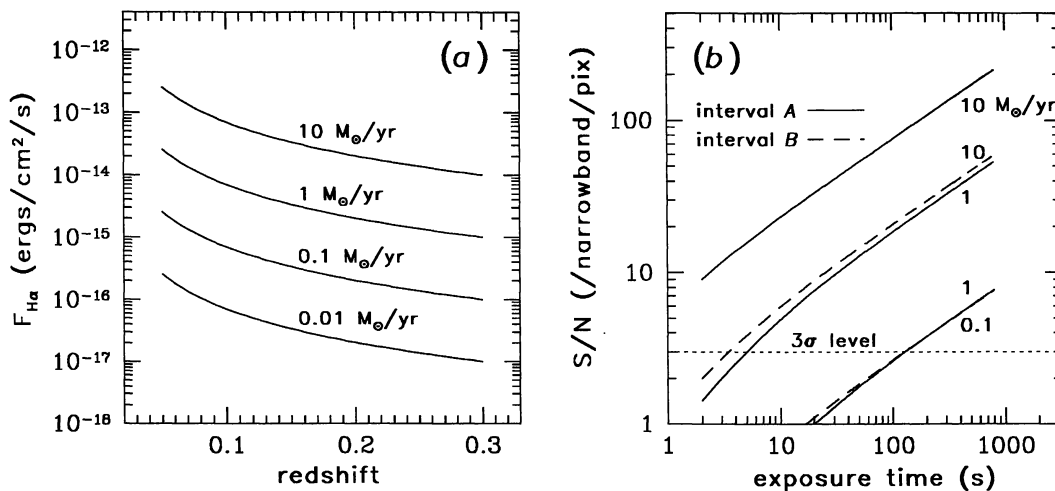* Resolution kept fixed during scanning.

Figure 1—Calculations used to optimise survey coverage. In (b) the solid and dashed lines correspond to redshift intervals
A $(0\cdot064 \leq z \leq 0\cdot101)$ and B $(0\cdot225 \leq z \leq 0\cdot259)$ respectively. See text for details.

from local counterparts to the FBGs, the results of which will provide much stronger constraints on the star-formation rates found at $z \lesssim 0 \cdot 1$ than have previously been possible.

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